TRAUMA TO THE GENITOURINARY TRACT*

PAUL C. PETERS, M.D.

Professor and Chairman
Division of Urology
The University of Texas Southwestern Medical School
Dallas, Texas

IN a small community hospital the general surgeon makes the initial diagnosis, performs the resuscitative measures, undertakes the necessary emergency or exploratory surgery (Figure 1), and perhaps does needed reconstructive surgery several months later. In a major city hospital, emergency-room physicians provide diagnostic and resuscitative functions, but emergency surgery is performed by another team of physicians. In both situations screening tests such as urinalysis, peritoneal flush, or quadrant tap of the abdomen (to ascertain whether intraperitoneal bleeding has occurred), the use of endotracheal tubes and oral airways, and splinting of major fractures are responsibilities of all contemporary physicians. Knowledge of cardiopulmonary resuscitation is mandatory for anyone practicing medicine.

Urologists are usually consultants when hematuria follows injury or when there is an obvious injury to the genitourinary tract. Sometimes, especially in a multiple injury patient, urologic injuries are not recognized initially, and the urologist is consulted later.

Over the years the trauma service at Parkland Hospital has developed a series of tests to minimize chances of missing a major urologic injury. After history and physical examination, the patient is inspected for points of entry of missiles or agents that might injure the urinary tract, and the urine is examined. If hematuria is present, the patient undergoes simultaneous excretory urography (intravenous pyelogram) and cystography or urethrocystography. Passage of a catheter for the cystogram provides information about a possible urethral injury, and both the excretory urogram and the cystogram help to exclude or to identify a major injury to the
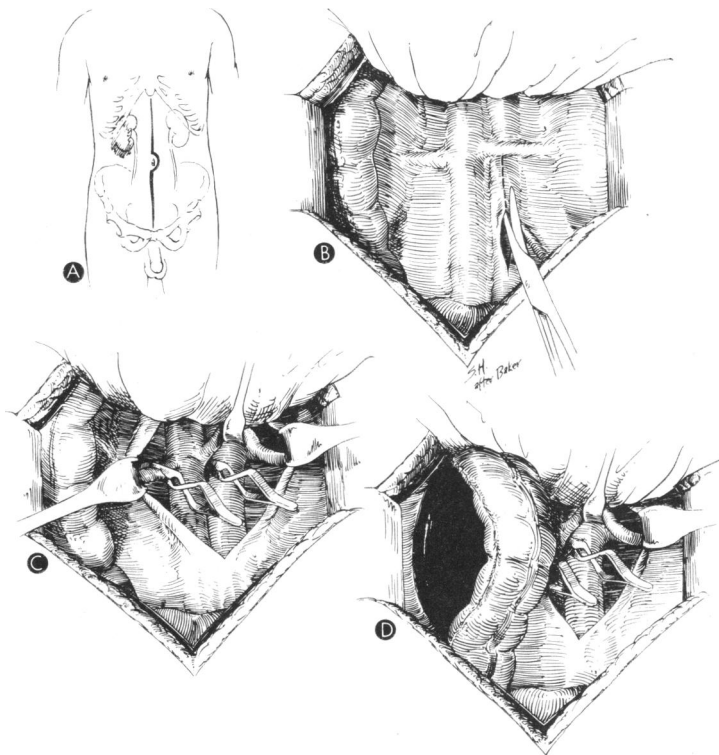
Fig. 1. A)   Midline abdominal incision for exploration of trauma patient. B)   Incision of the parietal peritoneum posterior medial to the inferior mesenteric vein to expose renal arteries. C) Exposure of renal arteries. D) Reflection of colon to explore kidney after renal arteries are secured and clamped with vascular occlusive clamps. Reproduced with permission from Peters, P.C. and Bright, T.C., III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery,* Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

urinary tract. A patient in whom we are wary of passing a catheter before contrast studies are obtained is one who has had a straddle injury and may have ruptured the urethra inferior to the urogenital diaphragm. In such patients a urethrogram with contrast material is performed before a catheter is passed for the cystogram.

The intravenous pyelogram (IVP) and the cystogram constitute the major screening procedures. If these studies are properly interpreted, they help one to ascertain with a 95% confidence limit whether the urinary tract has indeed been injured and help to assess the extent of the damage.
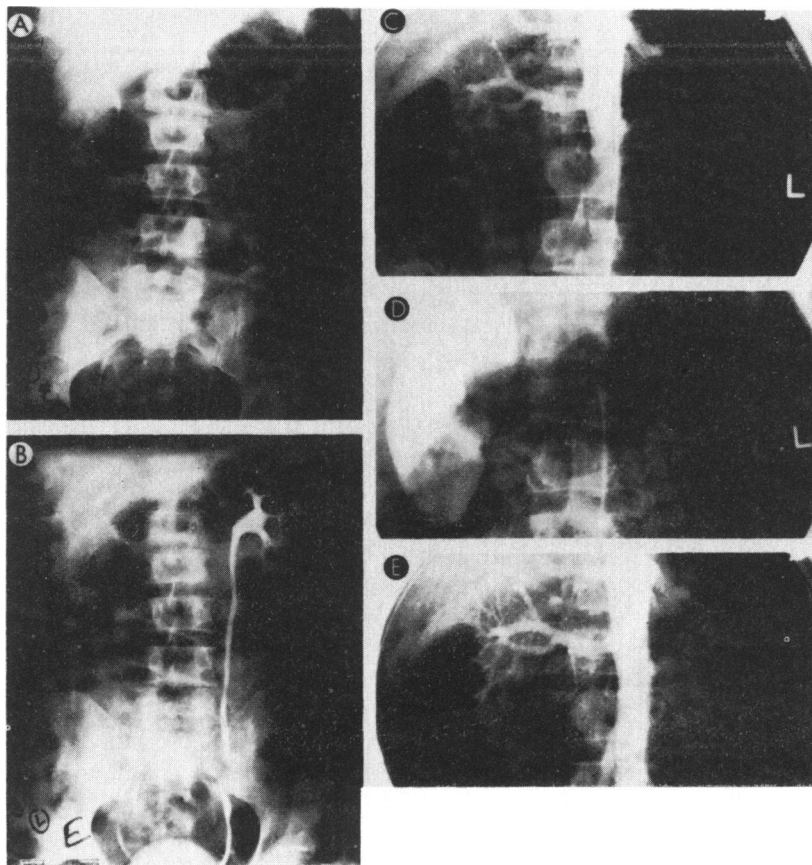
Fig. 2. A) Excretory urogram showing nonvisualization of the left kidney. B) Retrograde pyelogram showing normal collecting system. No urine was obtained from the left kidney. C) Arteriogram showing complete occlusion of left renal artery. D) Delayed phase of arteriogram showing dense nephrogram on right and continued nonvisualization of left kidney. E) Postoperative arteriogram showing unsatisfactory results from attempted repair the night of the injury. These cases are difficult to repair because of 1) varying periods of normothermic ischemia and 2) dissection of hematoma distally from original sites of arterial intimal tear resulting in considerable damage to the kidney from ischemia and thrombosis beyond the original site of the intimal tear. Reproduced with permission from Peters, P.C. and Bright, T.C. III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery*, Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

KIDNEY INJURIES

The kidney is essentially a thoracic organ. A kidney injury is suspected when a bruise is seen over the flank or when a point of entrance of a stab wound or a missile wound is situated posteriorly in the region of the 10th, 11th, or 12th ribs, high in the abdomen, or anteriorly in the lower lateral thorax. Rib fractures in this area, associated with gross hematuria, should therefore alert the examiner to possibile renal laceration or contusion. An excretory urogram is of diagnostic value in these cases because it allows classification of the renal injury as either minor or major injury. A patient who has a nonvisualized kidney by IVP is of major importance. If one kidney is apparent during IVP but the kidney on the opposite side is not visualized, the physician should immediately think of the mnemonic "APE"—i.e., the kidney is either absent, present (but diseased or injured), or ectopic. It is well to remember that some people are born with a kidney situated low in the pelvis (1/200) or even with both kidneys situated on one side (1/4,000), as in crossed ectopia, and that one in 400 has a congenital solitary kidney.

Of particular importance is a patient with gross hematuria and a history of slight or moderate flank injury. Preexisting kidney disease must be suspected. Gross hematuria is common following injuries sustained during vigorous contact sports. Preexisting hydronephrosis is always to be considered if gross hematuria follows slight injury in these patients.

Congenital anomalies are not always diagnosed during the neonatal period. In a New York Hospital study,[1] for example, only 4% of genitourinary abnormalities were detected at birth. Hence, it is not unusual to find a previously undiagnosed congenital abnormality in a teenager uncovered because of investigation of exaggerated symptoms and signs from slight injury.

A patient with a nonvisualizing kidney requires immediate investigation and surgical intervention because the injury is often an intimal tear of the renal artery (Figure 2). Such damage occurs because the kidney is quite mobile and moves one to three vertebral levels with each respiration. When the kidney is moved violently by a sudden external force, the renal artery is stretched, and the arterial intima, which cannot stretch as well as the media or the adventitia, is disrupted, which results in subintimal dissection of blood and subsequent thrombosis.

Arterial intimal disruptions are diagnosed by arteriography. The salvage rate for this injury remains consistently low because peripheral vasculature

beyond the tear is often obliterated by subintimal dissection and the kidney frequently has a thrombosed artery at the time of operation. Few cases are diagnosed in time to reconstruct the blood vessels and salvage the kidney. Thrombosis and normothermic ischemia have destroyed the kidney.

Other major renal injuries include a tear completely through the parenchyma into the renal collecting system and major lacerations that result in large perirenal hematomas. Usually, blunt injuries or those that result from deceleration forces (e.g., falling from a height or running into a solid wall, as in motor vehicle accidents) do not require immediate surgery.[2] If the kidney is visualized by excretory urography, a conservative approach that includes bed rest, replacement transfusions, frequent observation, and serial determinations of urine and blood hematocrit may be pursued. Clotting occurs in the parenchymal defect, and resolution of the clot and fibrin over the next 10 to 21 days usually results in functional and anatomical restoration of the kidney. More than 90% of patients with blunt genitourinary injuries recover without need for operation. Indications for surgical intervention remain: failure of support systems, continuing hemorrhage, sepsis, or shock.

Whereas most blunt genitourinary injuries usually require no surgical intervention, all penetrating injuries require surgical exploration. A high incidence of associated injuries is common in genitourinary injury, and these associated injuries constitute the major risk to the patient. Laceration of the liver, laceration of a major blood vessel, or laceration of the spleen (for which surgical removal is usually necessary to prevent exsanguination) are examples of such associated injuries.

Fifteen percent of all renal injuries may be classified as major. (In considering major renal injuries as a group, 85% can be triaged into a group to be managed conservatively or nonoperatively. Five percent are essentially destroyed and kidneys must be removed, i.e., comminuted kidneys, pedicle arterial injuries with infarction.) Only 10% of all renal injuries (usually those with major lacerations involving the collecting system with small amounts of extravasation) require judgment decisions as to the necessity of reconstructive surgery.

URETERAL INJURIES

Ureteral injuries are uncommon: only 19 isolated ureteral injuries were reported during World War I and 25 during World War II.

A unique ureteral injury is seen in a child who suffered sudden deceler-

ation, as in falling from a height or in a motor vehicle accident. In such cases the kidney may be avulsed from the ureter at the ureteral-pelvic junction at the moment of hyperextension of the spine. Bilateral injuries of this type combine with anuria. Children are more prone to this injury than adults because of the increased mobility of the kidney in childhood. The perirenal fat is sparser than in the adult.

Missile wounds of the ureter can be classified as high-velocity or low-velocity missile injuries. High-velocity missile injuries (2,200 to 2,700 ft./sec.) usually result from deer rifles or military weapons, whereas low-velocity missile injuries (700 to 900 ft./sec.) may result from guns used in civilian pursuits, such as the 22-caliber pistol or 38-caliber pistol. The evaluation of "blast effect" of high-velocity missile injury is one of the incompletely solved problems in the management of the urologic trauma patient. When a missile strikes the ureter, proximal and distal tissue necrosis occurs, but the extent of this necrosis may be difficult to evaluate during the first few hours after injury, particularly in high-velocity injuries. If there is a question as to whether the patient was shot by a high-velocity or by a low-velocity missile, a plain roentgenogram of the abdomen may solve this question. If the missile is still embedded in the body, it can be assumed that it is most likely a low-velocity missile because a high-velocity bullet usually passes through the patient.

Ureteral injuries are usually treated by end-to-end anastomosis of the severed ends. In injuries of the juxtavesical ureter, reimplantation into the bladder may be considered. Defects of 6 cm. or less can be overcome by mobilizing the kidney with attached ureter and mobilizing the bladder. When the ureteral defect is large, it may be necessary to divert the urine temporarily by nephrostomy and pelvis closure and replace the ureter later with a segment of ileum. A patient with ureteral injury associated with major vascular injuries and unobtainable blood pressure or shock may be treated simply by passing a stent through the ureteral defect into the kidney followed by repair of the ureter at a later date. This temporary measure considerably shortens the general anesthesia time and allows the patient to be taken quickly from the operating theater to the recovery room for resuscitation.

If the patient is in no immediate danger, definitive reconstruction is preferred at the initial operation when other injuries are also being repaired. An end-to-end anastomosis of the ureter over a stent is the procedure of choice (Figure 3). A Penrose drain is placed near the site of the
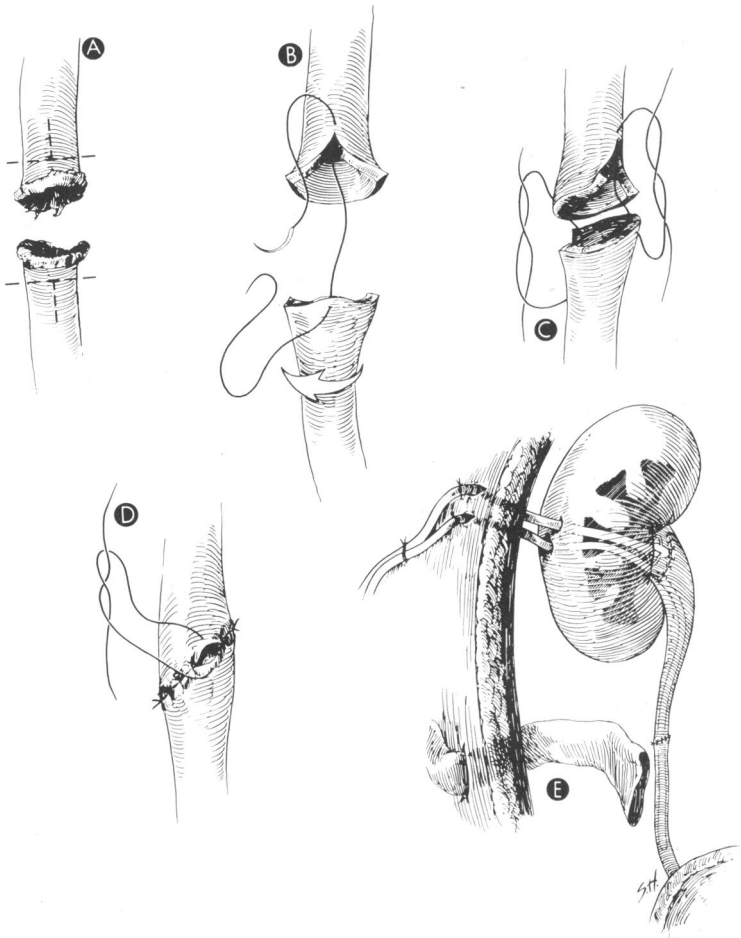
Fig. 3. A) Blast injury to the ureter showing area proposed for debridement. B) Interrupted spatulated anastomosis begun. C and D) Completion of anastomosis. E) Completed procedure showing nephrostomy in renal pelvis, stent going through pelvis and down ureter to bladder, and Penrose drain near site of ureteral repair. Reproduced with permission from Peters, P.C. and Bright,T.C.,III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery*, Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

ureteral repair in case the repair breaks down secondarily to unrecognized necrosis from the blast effect. The drain provides the patient with appropriate drainage if a ureteral leak subsequently occurs and negates the need for an interposed operation merely for drainage in a patient who is ill-prepared for it.

BLADDER INJURIES

Bladder injuries are most easily classified as extraperitoneal ruptures and intraperitoneal ruptures. Intraperitoneal rupture of the bladder usually occurs in someone who has violated the first urologic axiom, namely, never to enter a vehicle with a full bladder. If that individual sustains a blunt force to the abdominal wall—as in sudden deceleration in a motor vehicle accident—the bladder ruptures at its weakest point, the dome, and its contents spill into the peritoneal cavity. Intraperitoneal bladder rupture is usually easily recognized by cystography. However, it is essential to inject a large volume of contrast material, as much as 250 ml., to avoid missing an intraperitoneal rupture. Failure to inject an adequate volume of contrast material may produce misleading results: the roentgenogram appears to show a small, well-filled bladder when, in fact, it has previously ruptured. A larger volume of contrast material cannot be contained by a ruptured bladder, and so it spills into the peritoneal cavity. There is no need to worry that the bladder has been ruptured by the larger volume because it is almost impossible to rupture a normal bladder by contrast media.

Bladder ruptures are easily repaired by suprapubic cystotomy. Alternatively, in a patient with no other major injuries, and particularly in women, the bladder may be repaired in three layers, leaving an indwelling catheter per urethra until urine is clear yellow (three to 10 days).

In extraperitoneal rupture of the bladder, an associated pelvic fracture is often a problem. In fact, in these cases a jagged fragment of bone usually has torn the bladder. Repair of extraperitoneal rupture of the bladder is done by cystotomy, closure of the bladder laceration, and extraperitoneal drainage through a Penrose drain.

It is important to differentiate extraperitoneal rupture of the bladder from rupture of the urethra superior to the urogenital diaphragm. In extraperitoneal rupture, the bladder shadow—often in the shape of a teardrop because of an associated pelvic hematoma compressing the bladder—descends to the symphysis pubis. In contrast, with rupture of the urethra superior to the urogenital diaphragm, the bladder—still full because the action of the bladder neck holds the urine—ascends, accompanied by the prostate and supramembranous urethra, to a point high in the pelvis away from the symphysis pubis.
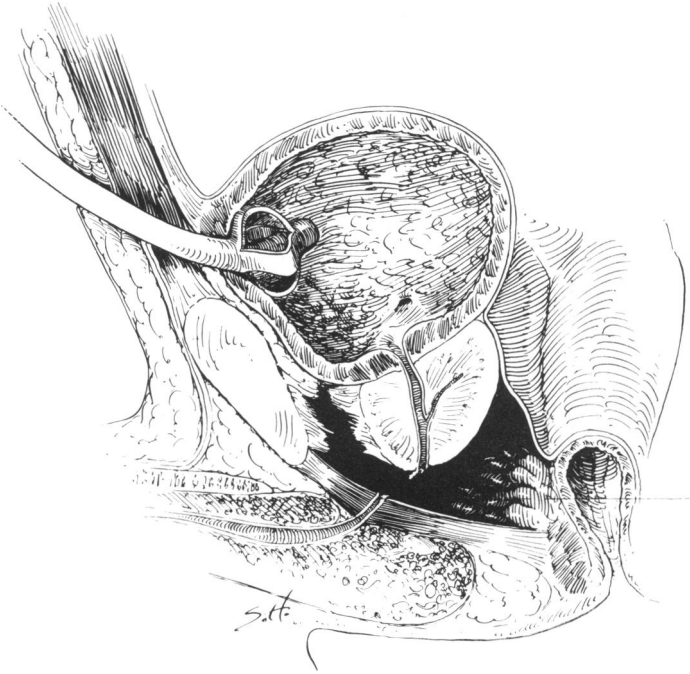
Fig. 4. Proper placement of the suprapubic tube away from the trigone and brought out obliquely as the first step in the surgical management of rupture of the urethra superior to the urogenital diaphram. Reproduced with permission from Peters, P.C. and Bright, T.C., III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery*, Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

URETHRAL INJURY

Posterior urethra. Rupture of the urethra superior to the urogenital diaphragm is a serious injury because it is usually a complete rupture. Diagnosis of this injury is based on roentgenographic visualization of an elevated bladder and prostate silhouette.

Although still a subject of slight controversy, results have been encouraging when using cystostomy alone initially, with reconstruction at a later date. Thus, when rupture of the urethra superior to the urogenital diaphragm is diagnosed immediately after the time of injury, the physician should simply introduce a suprapubic tube, using local or general anesthe-

sia (Figure 4). Three to four months are then allowed for resolution of the pelvic hematoma and descent of the prostate. At the end of that time, reconstruction of the urethra by the peritoneal or retropubic route is performed.

Infrequently, large fragments of bone from severe comminuted fractures of the pelvis impede the descent of the bladder and prostate to their normal positions. These individuals should be immediately treated by cystotomy and, after a few days, when their condition is stabilized, taken to the operating room. The bone fragments are then removed, and an attempt is made to align the bladder and the prostate. Such cases comprise the sole exception to those with a ruptured urethra superior to the urogenital diaphragm who should not be treated by immediate cystotomy and delayed reconstruction.

There should be no attempt to incise a pelvic hematoma at the time of injury because this increases the risk of continued hemorrhage and enhances the opportunity for pathogens to invade the hematoma.

There are three major consequences of rupture of the urethra superior to the urogenital diaphragm: impotence, incontinence, and stricture of the urethra. The incidence of these distressing complications, which once appeared in 54% to 100% of cases, [3] can be almost completely avoided by utilizing initial cystotomy with delayed reconstruction.

Anterior urethra. Diagnosis of ruptures of the urethra below the urogenital diaphragm depends initially on the history. This condition is usually caused by a straddle injury, often resulting from falling while astride a bicycle or a fence.

Ruptures of the urethra below the urogenital diaphragm may be treated initially by cystotomy when the injury is severe. The patient who reports a straddle accident should not be asked to urinate, because if he has ruptured his urethra he will urinate into the tissues, thereby complicating the injury. Urethrography should be attempted first. For patients in whom a catheter has already been passed (e.g., the patient referred from a small community hospital) and in whom a urethral injury is suspected because of bleeding around the catheter or because of failure of the catheter to drain properly, contrast material may be injected into the urethra alongside the catheter. In this way, a satisfactory film can usually be obtained and may obviate the need to remove the catheter (Figure 5).

Cystotomy with later repair is preferred for major injuries to the urethra below the urogenital diaphragm. For injuries that involve a small segment
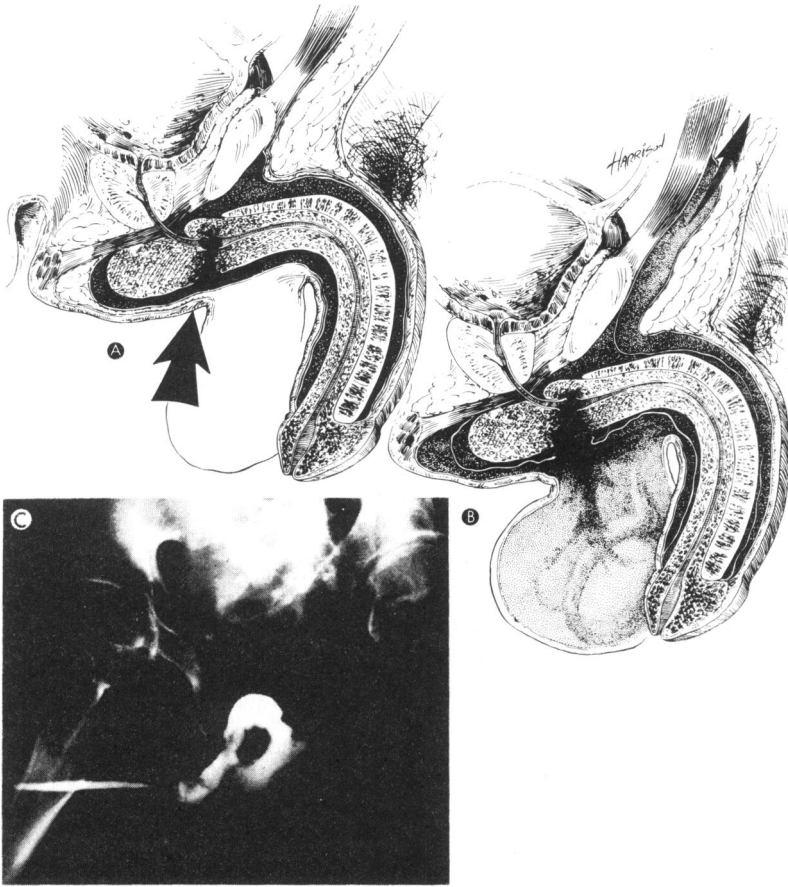
Fig. 5. A) Rupture of urethra contained by Buck's fascia. B) Rupture of the urethra contained by Colles' fascia. C) Urethrogram in rupture of urethra inferior to urogenital diaphram. Reproduced with permission from Peters, P.C. and Bright, T.C., III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery,* Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

of the urethra, e.g., those caused by laceration or by the entry of a sharp instrument, immediate reconstruction with end-to-end oblique anastomosis may be performed. For minor injuries (e.g., mucosal lacerations) to the urethra below the urogenital diaphragm, an indwelling catheter can often serve as a stent until healing occurs.

PROSTATIC INJURIES

Injuries to the prostate are usually associated with injuries to the urethra superior to the urogenital diaphragm. The prostate is torn from its attach-
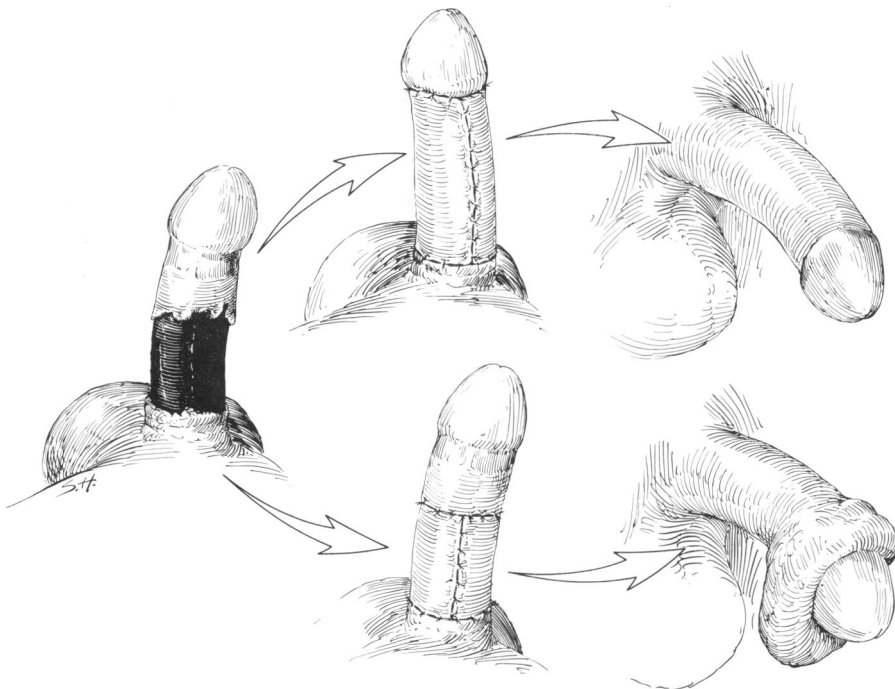
Fig. 6. Upper half shows proper reconstruction of distal penile skin injury. Inferior part of photograph shows interposition graft improperly placed with subsequent lymphedematous ring near corona. Note that in distal penile skin injuries bits of remaining skin should be excised to the level of the coronal sulcus and a split thickness skin graft applied from the coronal sulcus to proximal intact tissues. Reproduced with permission from Peters, P.C. and Bright, T.C., III: Management of Trauma to the Urinary Tract. In: *Advances in Surgery,* Longmire, W.P., Jr., et al., editors. Chicago, Year Book Med. Publishers, 1976, vol. 10.

ments to the urogenital diaphragm. Lacerations of the prostate usually require only simple closure and drainage. The exception is a laceration associated with a urethral rupture. These injuries are treated by mobilizing the prostate and reanastomosing the prostatic urethra to the supramembranous urethra, a procedure usually performed about three months after the injury.

GENITAL INJURIES

Penile injuries. Penile injuries include skin and erectile tissue injuries and urethral injuries as well as injuries to the corporal bodies. Diagnosis

may be made by injecting the corpora cavernosa with a contrast material to determine the exact site of the laceration. This procedure must be used with caution because fibrosis of the corpora may ensue. When corporal lacerations are recognized a few minutes or hours after the injury, an incision is made through the skin of the penis to expose the laceration, the clot is evacuated, and the incision is closed with interrupted chromic gut sutures.

The repair of avulsing injuries of the penile skin deserves some mention. It is generally considered good policy not to discard skin when there is an avulsing or sleeve-like injury to the penis. Distal skin should be excised to the level of the coronal sulcus and a split-thickness graft placed between the coronal sulcus and the site of the proximal intact skin. Efforts to save small bands of distal penile skin result in improper lymphatic drainage through the interposed graft and may cause a cosmetically deforming edematous "doughnut" to form around the penis distally (Figure 6).

Scrotum. All penetrating injuries to the genitalia are explored, and blunt injury to the scrotum demands immediate exploration in a significant number of cases, particularly if physical examination reveals a large scrotal mass. Often, testicular hematomas and avulsions are found.

Injuries to the scrotum are best managed by debriding all necrotic tissue (and, in the case of penetrating injury, bits of foreign material) with subsequent closure of the tunica albuginea of the testis. The testis should not be left open to drain, as testicular tubules will follow the course of the drain to the exterior.

Testicular ruptures are treated by debridement of necrotic tissue and closure of the tunica albuginea of the testis. However, in penetrating injury there is a risk of contamination that may be minimized by extremely meticulous debridement of all foreign material.

The scrotum has remarkable powers of regeneration and a good blood supply, and can often be dissected to form a pedicle flap. It may therefore be useful for repairing major defects in the adjacent lower abdomen.

When the scrotum is completely avulsed, the testes are exposed, and if there are no fragments of skin left for regeneration, the problem is one of coverage. In these cases it is best to place the testes in a pouch of superficial skin in the thigh. The temperature of the abdomen and deep thigh is about 99°F., and the temperature of the superficial thigh is almost 10° lower—the lower temperature favoring spermatogenesis.

COMPLICATIONS

Infections are a common complication of urologic surgery. Extravasated urine often becomes infected if the extravasation is not recognized promptly and drained. In trauma patients the complicating infection often occurs when there are multiple injuries, particularly when the bowel and urinary collecting system are simultaneously involved. Urine and feces may temporarily become mixed, thus contaminating the urinary tract. The infecting organisms are diagnosed with cultures and quantitative colony counts, and appropriate antibiotic therapy is then instituted.

Preliminary fecal diversion is indicated in injuries that result in an admixture of fecal and urinary streams, i.e., colovesical injuries. This minimizes the danger of urinary tract infection and fistula and enhances primary healing of the urinary tract.

REFERENCES

1. Felton, L. M.: Should intravenous pyelography be routine procedure for children with cryptorchism or hypospadias? *J. Urol. 81*:335-38, 1959.
2. Peters, P. C. and Bright, T. C., III: Blunt renal injuries. *Urol. Clin. North Am. 4*:17-28, 1977.
3. Peters, P. C. and Bright, T. C., III: Management of trauma to the urinary tract. *Adv. Surg. 10*:197-244, 1976.